

SEDIMENTATION IN JERVIS BAY

G. TAYLOR

Department of Geology, Australian National University

(Communicated by Dr. K. A. W. Crook)

[Accepted for publication 23rd June 1971]

Synopsis

Jervis Bay is underlain by a lenticular sand body occupying a river valley cut in Permian sandstones and siltstones. The sediment covers an area of 84 km.² with an average thickness of 20 m.

Two zones are evident, a low energy central zone consisting of a sublitharenite containing less than 85% quartz and a marginal high energy zone containing quartz arenites and sublitharenites containing greater than 85% quartz.

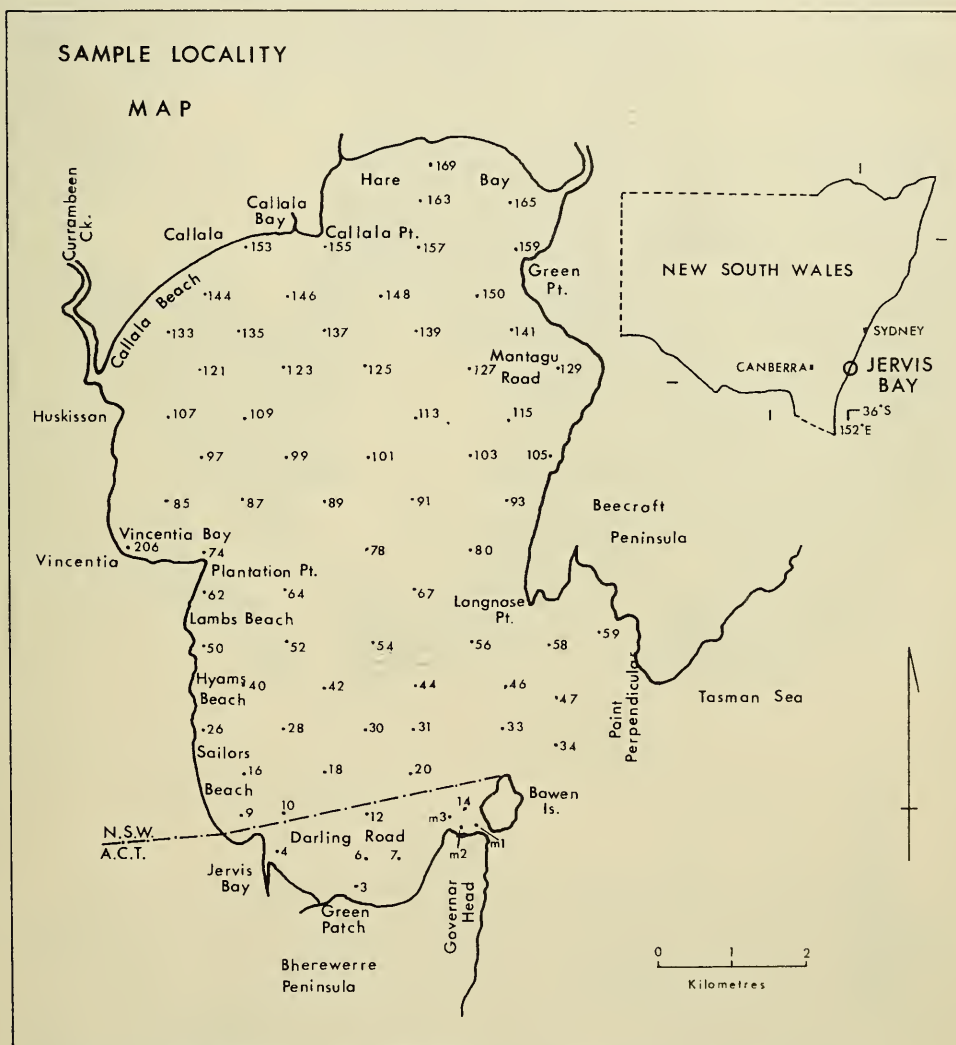


Fig. 1. Map showing local names referred to in the text and sample localities.

INTRODUCTION

The recent marine sediments in Jervis Bay have been investigated (Taylor, 1970) and an attempt made to delineate the character of the sediments, the processes involved in sedimentation, and the history of the embayment. This was carried out by surface sampling (Fig. 1), continuous seismic profiling and a detailed examination of the hydrology, bathymetry and Quarternary geology of the bay.

REGIONAL GEOLOGY

Jervis Bay is an embayment in the coastline of New South Wales approximately 84 km.² in area with its entrance 6 km. east of the general line of the coast. It is situated in a gently folded sequence of Lower Permian sublitharenites and siltstones (Rose, 1966) (Fig. 2). Permian rocks crop out over half of the coastline of the bay; the remainder is bordered by beaches and beach ridges dating back to the Pleistocene (Walker, 1967).

Only one stream of any significance, Currambeen Creek, drains into the bay, and most of its sediment load is deposited before reaching the bay. Other streams deposit their load in back-swamps and lagoons around the bay.

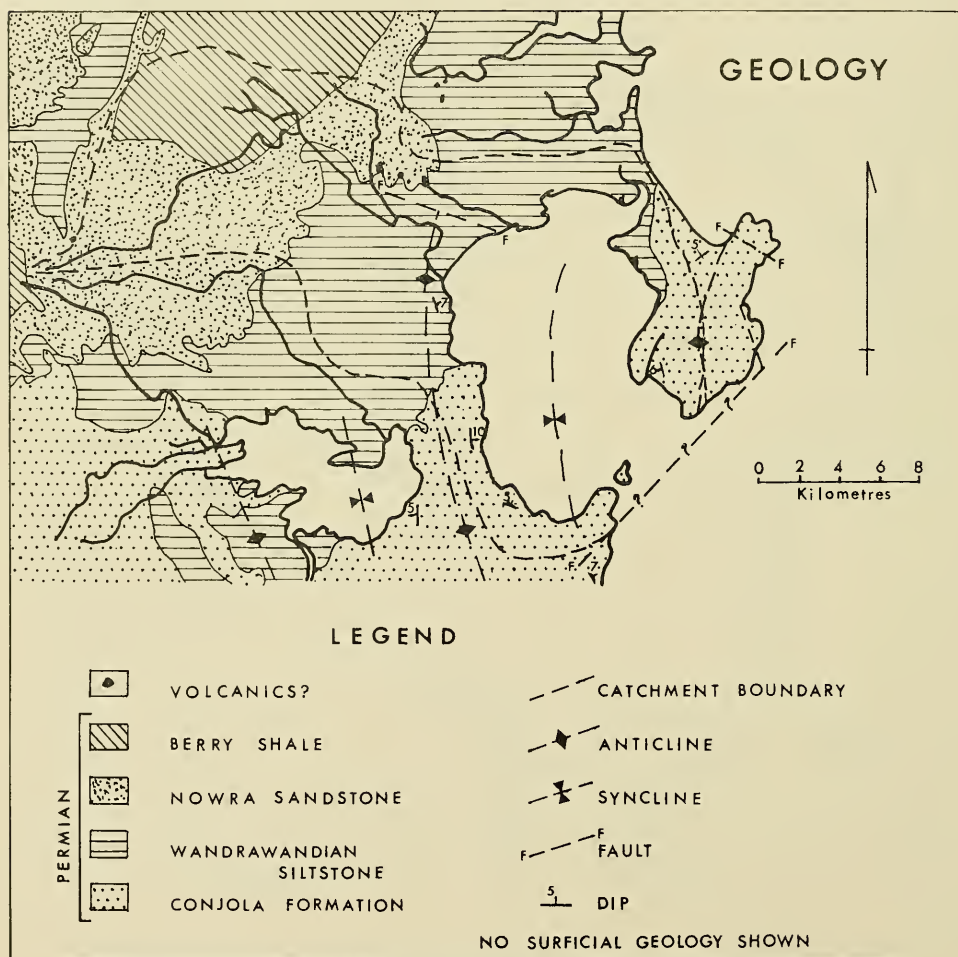


Fig. 2. Catchment Geology of Jervis Bay and of streams entering the bay.

BATHYMETRY

R.A.N. Chart AUS. 80 shows that the bottom slopes gently to 26 m. from the north, west and south, the eastern shoreline sloping more steeply (Fig. 3). The entrance to the bay reaches a maximum depth of 41 m.



Fig. 3. Bathymetry of Jervis Bay.

HYDROLOGY

No full-scale hydrological survey has been conducted in Jervis Bay. A limited survey was conducted in the southern half of the bay by the author in the summer of 1968. Three water layers were present: an upper layer up to 17 m. thick, with an intermediate layer up to 4.5 m. thick, and a lower layer up to 20 m. thick in the deeper parts of the bay. The mean summer surface and bottom temperatures are 23.1°C . and 19.8°C . respectively and average chlorinities are 19.65‰ . The bay has a similar hydrographic environment to other open estuaries in eastern New South Wales (Rochford, 1951).

The predominant swell entering the bay is from the south-east, causing turbulence on exposed shores all year to a depth of 19 m. Predominant winds are north-easterly and north-westerly, with southerly storm winds. Hence all shorelines within the bay are subject to continual wave activity, except south-facing shores at the north end of the bay, which are only affected during southerly storms.

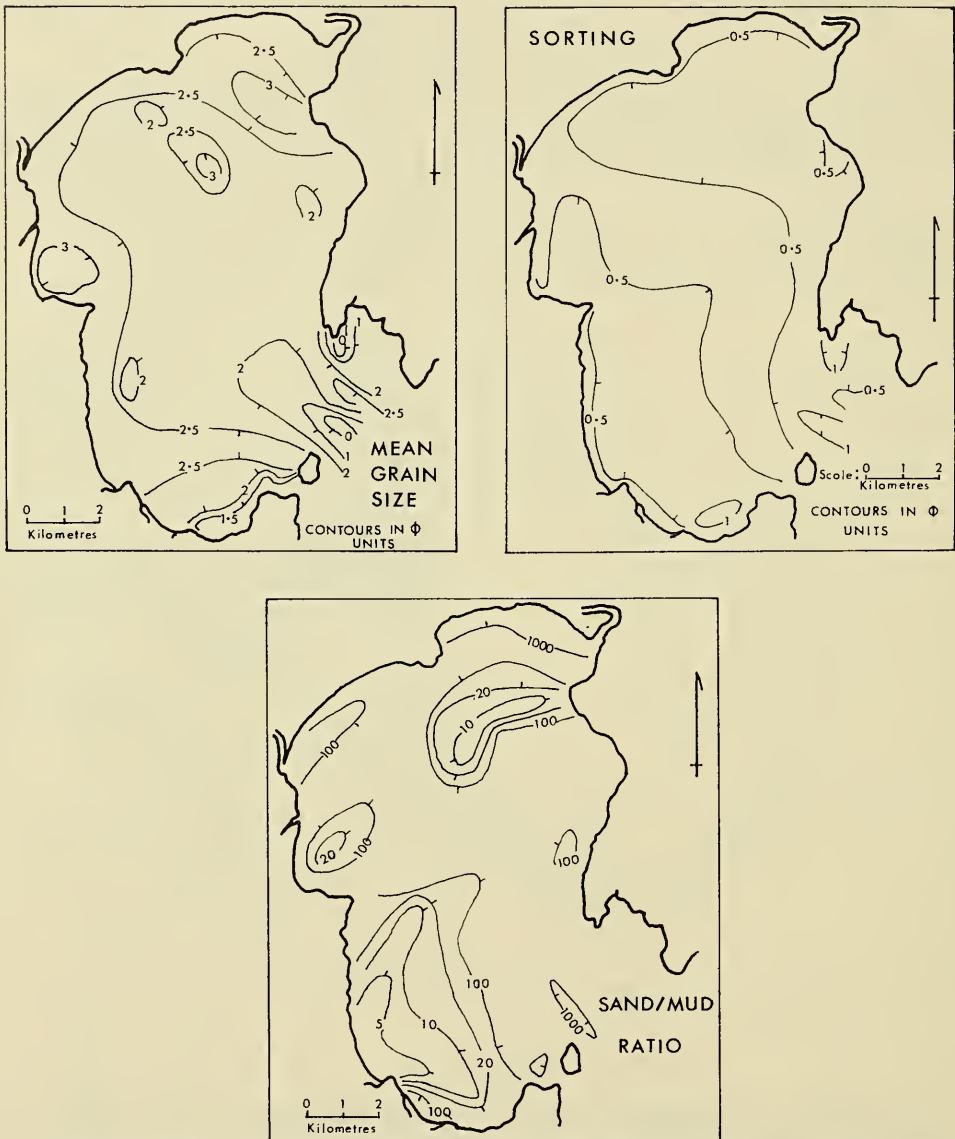


Fig. 4. Maps showing the surface distribution of grain size, sorting and sand/mud ratios in Jervis Bay.

FIELD AND LABORATORY PROCEDURES

Grab samples of the top 15 cm. of sediment were taken at 1.6 km. intervals on an E.-W. grid and at 0.8 km. on a N.-S. grid. The samples were split, desalinated, and dried in preparation for mechanical and mineralogical analysis.

MECHANICAL ANALYSIS

Measurements of grainsize, sorting and sand/mud ratios were made using techniques described by Folk (1968). The mean size and sorting coefficients were calculated from frequency data using formulae derived by Folk and Ward (1957).

The mean size of sediments, excluding the mud fraction, varies from 0.64ϕ to 3.37ϕ . The areas of coarse sediment are confined to regions of high energy in the entrance to the bay. The general trend in the bay is a fining marginwards (Fig. 4); off Callala Beach and Darling Road this trend is masked by growth of

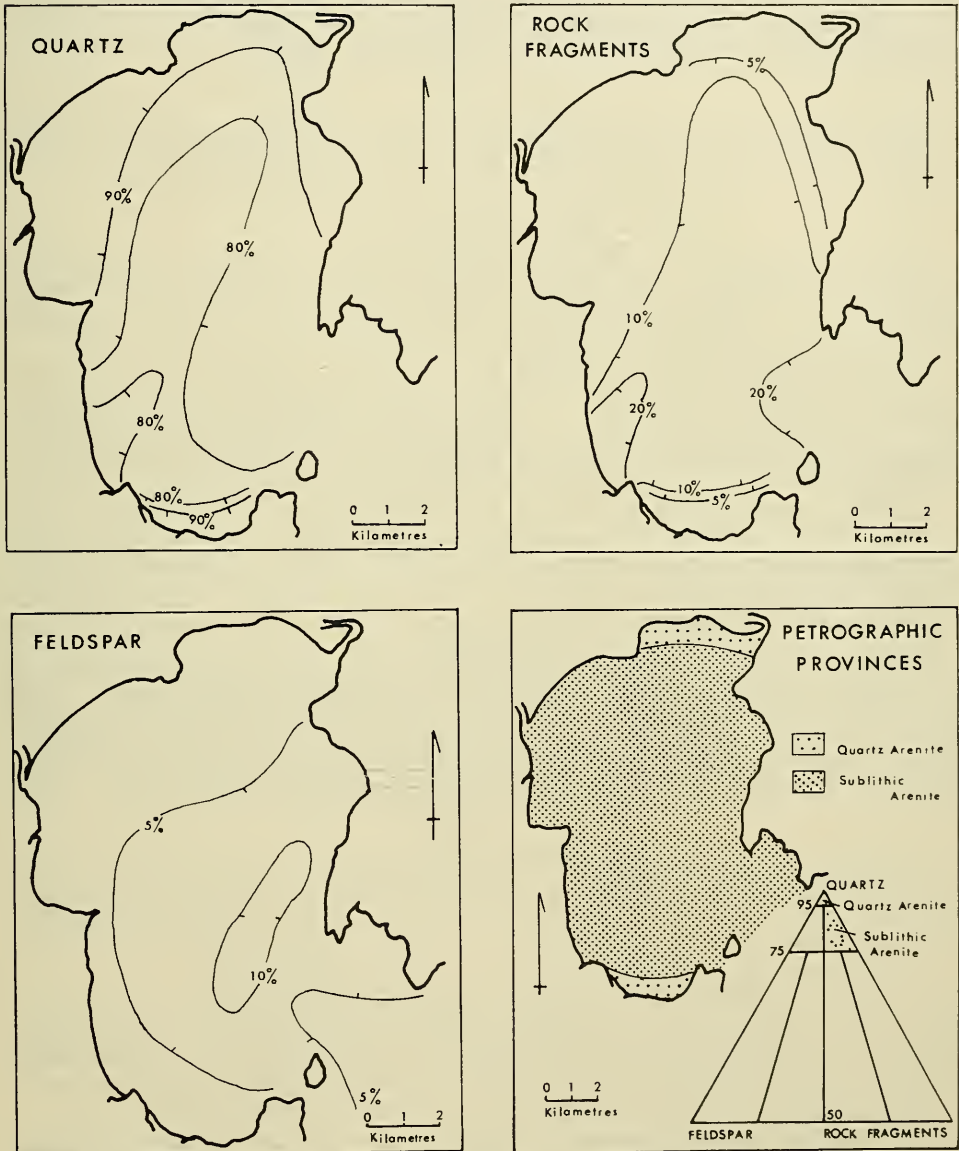


Fig. 5. Maps showing the surface distribution of quartz, rock fragments, feldspar and petrographic provinces in Jervis Bay.

molluscan fauna. The mud fraction has a mean size in the coarse silt range (4.76ϕ to 5.01ϕ) with less than 5% being finer than 7ϕ .

The marginal sediments are slightly better sorted than those towards the centre (Fig. 4). The coarse sediments in the entrance and in areas of molluscan growth are poorly sorted. The sorting values vary from 1.90ϕ units to 0.33ϕ units, and the areal distribution pattern follows that for mean size, i.e. the better sorted sediments occur in marginal regions and more poorly sorted areas are central.

No sediment contains more than 20% mud, and most contain less than 1%. The sand/mud ratio (Fig. 4) varies from infinity to 1.75. The regions of high mud concentration occur in areas protected from the south-easterly swell, e.g. Vincentia Bay, Green Point and off South Sailors Beach.

MINERALOGY

The composition of the terrigenous sediments was determined by point counting, and the amount of carbonates by solution in hydrochloric acid.

LIGHT MINERALS

The abundance of quartz varies between 73% and 96% of the total terrigenous constituents. The higher concentrations are restricted to the marginal regions (Fig. 5). The majority of quartz is well rounded and monocrystalline, indicating a high degree of maturity.

Rock fragments make up between 3% and 21%, the highest concentrations being in the central region (Fig. 5). The majority of rock fragments are sandstone from the seachiffs surrounding the bay. Minor basic igneous and siltstone fragments are also found. These rock fragments are all unstable and reworking destroys them, hence their paucity in the marginal zones.

Feldspar occurs in minor amounts in the central region (Fig. 5) and in areas of active erosion of the Nowra Sandstone (Rose, 1966). It is mostly highly altered and contains included mica. It is mostly a sodium-calcium variety with little potassium feldspar.

CARBONATES

The carbonates locally contribute up to 80% of the sediment in the areas of strong tidal currents near the entrance, and of abundant faunal growth. The greater part of the sediments however contain between 5% and 20% carbonate (Fig. 6). The carbonates are made up of complete and fragmented remains of bivalves, gastropods, echinoids, forams, polyzoans and ostracods, the last four being more common in the southern region of the bay.

PETROGRAPHIC PROVINCES

The petrographic sand types have been classified according to Folk (1968). Sublitharenites cover most of the bay with small areas of quartzarenite at the north and south end (Fig. 5).

The abundance of quartz in marginal zones of high energy and fine grain size and the comparative lack of rock fragments in these zones is presumably due in part to the break-up of rock fragments. Since the rock fragments are mainly of a sublitharenite, the contribution to the sediments from their break-down is essentially quartz. This process is effected less rapidly in areas of lower energy (i.e. central region) and hence rock fragments survive longer.

The erosion of Nowra Sandstone (Rose, 1966) around the eastern margin of the bay continuously supplies rock fragments in that region, hence although it is a high energy coast, rock fragments are relatively abundant.

Feldspars are more abundant in the deeper lower energy zones of the bay, presumably because of their instability in areas of continual wave activity.

These provinces are masked to some extent by abundant carbonate detritus present in some localities.

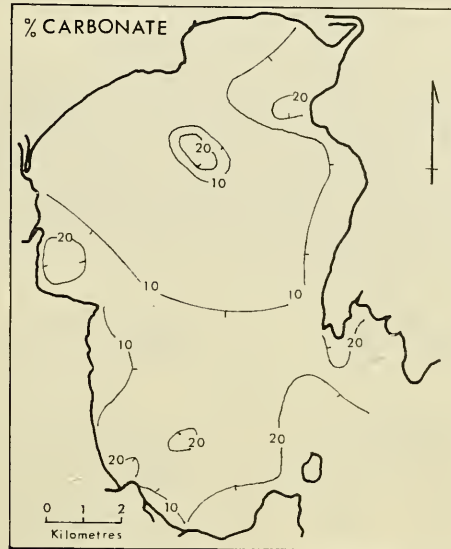


Fig. 6. Map showing the surface distribution of the carbonate components of the sediment.

HEAVY MINERALS

The heavy minerals from 10 g. splits of sediment were separated by use of tetrabromethane. The sizes of the grains separated varied from 0.08 to 0.12 mm. and from less than 0.01% to 0.9% of the marine samples by weight and up to 63% in one beach concentrate. The separates were then examined and "species" counts made on at least 200 grains. Eighteen different "species" were noted, of which 50% (mean percentage) were opaques, including magnetite, hematite, leucoxene, pyrite, cassiterite and ilmenite. Minor constituents (monazite, rutile, hornblende, andalusite, corundum, garnet, spinels and biotite) make up 14%. The remaining minerals, zircon (2.5%), tourmaline (18%) and epidote (16%), are of environmental significance.

The provenance of these minerals is the Permian sediments in the catchment and seacliffs and from reworking of older unconsolidated sediments, themselves originating essentially from the Permian.

From the heavy mineral provinces (Fig. 7)

(zircon province	..	8%	zircon
Tourmaline province		20%	tourmaline
epidote province	..	15%	,,)

it is clear that zircon predominantly occurs around the margins of the bay and that tourmaline and epidote are restricted to the deeper central areas.

These distributions reflect the energy conditions in the bay and the specific gravity of zircon and tourmaline/epidote. The heavier mineral, zircon, is concentrated in the high energy zones and the lighter minerals, tourmaline and epidote, are concentrated in the deeper low energy zones (Fig. 7).

MUD FRACTION MINERALOGY

Between 40% and 60% of the muds are composed of biogenic carbonate debris. A variety of terrigenous components are present in the muds, the most abundant being quartz (>90% of the total terrigenous fraction in all samples analysed). Other minerals found in minor percentages only include feldspar, kaolinite, chlorite, heavy minerals and muscovite.

SEDIMENTARY HISTORY

A continuous seismic reflection survey of 10 traverses (Fig. 8) using a low output "sparker" system with a visual display recorder, showed that Jervis Bay is an infilled river valley formed during a Pleistocene low stand of sea level (Fig. 8). The sediments deposited in these valleys have since been reworked and redistributed by at least one marine transgression. Examination of the records shows some patches of relict sediment which have been interpreted as lag-deposits of either the original fluvial sediments or sediments redistributed from an earlier marine transgression.

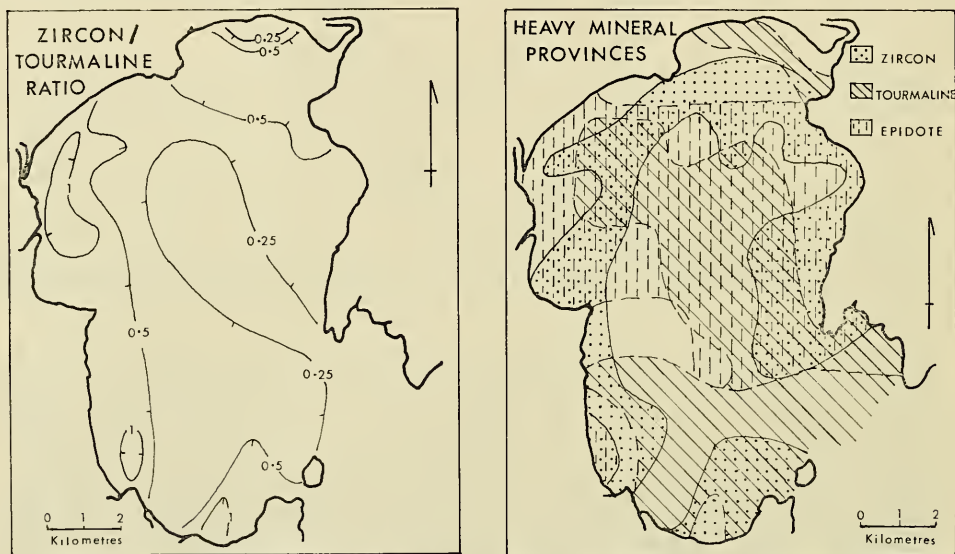


Fig. 7. Heavy mineral provinces and zircon/tourmaline ratios of the surface sediments in Jervis Bay.

Another source of sediment is the erosion of the seacliffs during the various interglacial high sea levels. No sediment is entering the bay from the shelf under present conditions; however, this may not have been so during Pleistocene regressions and transgressions. The contribution of sediment from outside the bay while the bay was open at Hare Bay is unknown. A. D. Albani (pers. comm.), from seismic profiles in the Hare Bay region, confirms that the bay was at one time open to the sea at the north end also. Sediment in the bay is up to 30 m. thick in the deeper central areas, thinning to zero at the margins and over a basement high in the entrance region (Fig. 8). The thickness under the areas of beach-ridge development (e.g. Callala Beach) is unknown.

Evidence of sedimentary structures is absent from both the seismic records and from grab samples. This is probably due in part to disturbance of the materials during sampling; however, in the few undisturbed samples taken few structures were apparent, owing to destruction by bioturbation.

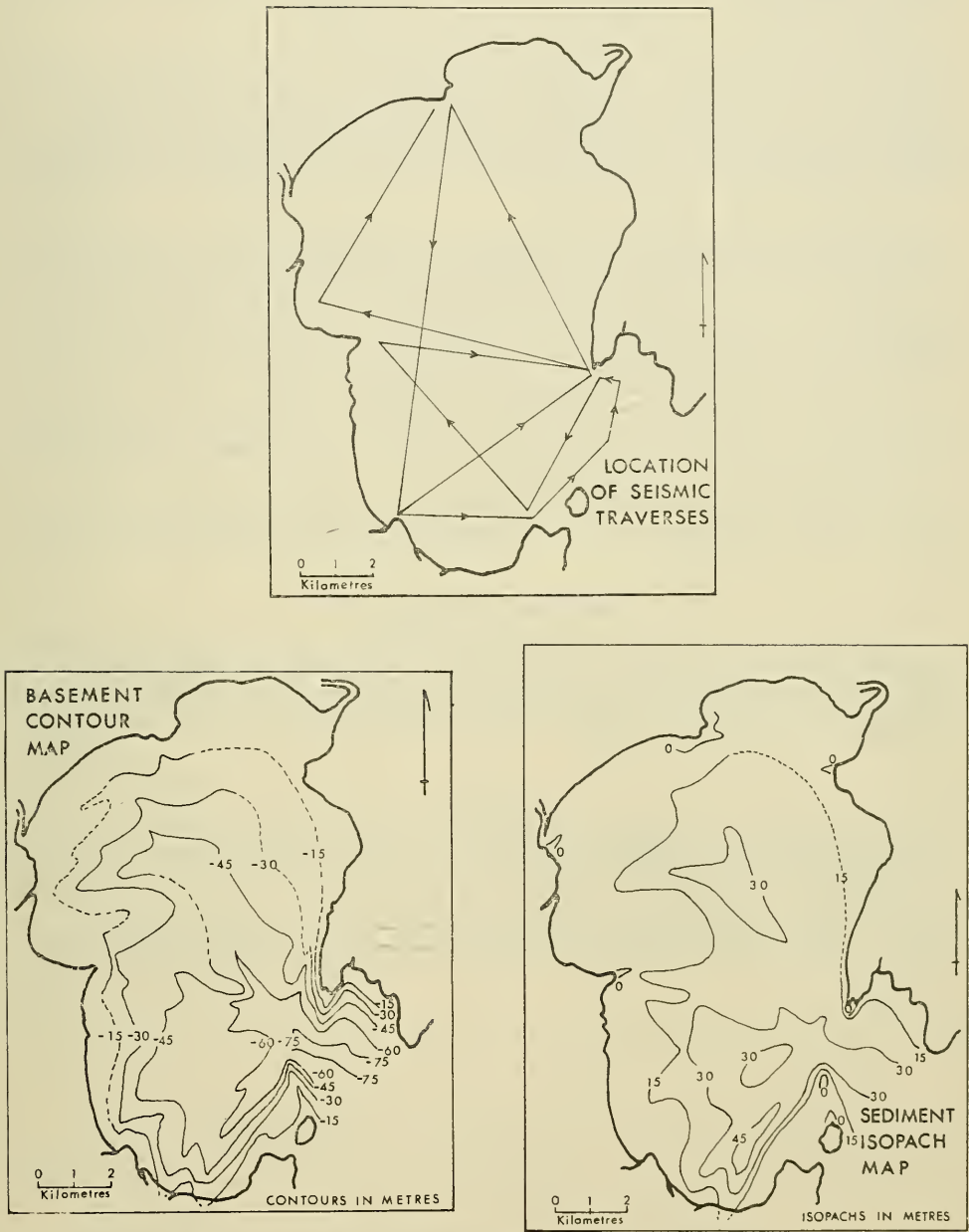


Fig. 8. Maps showing the location of seismic traverses, the configuration of the solid substratum and an isopach map of the unconsolidated sediments.

DISCUSSION

Sedimentation in Jervis Bay forms two distinct zones, the centre and the margin. These zones of deposition are based on differences between sediments forming in them.

The grain size in the marginal zone is finer than that in the centre (2.44 ϕ and 2.11 ϕ respectively). This results from the more intense reworking by wave activity in the marginal zones and the removal of silt, clay and carbonates to the central zone. The carbonate grains are significantly different in shape from the bulk of the sediment in the marginal zone and are hence unstable in this area. Thus it follows that the central zone is enriched in silt, clay and carbonates with respect to the marginal zone.

As a result of the continual reworking in the marginal zone and the rejection of unstable particles, marginal sediments are better sorted (0.49 ϕ units compared to 0.69 ϕ units) than those in the central zone. The energy difference between the central and marginal zones also controls the mineralogy. Sedimentary rock fragments are broken down into their constituents, the major one being quartz. Hence quartz is more abundant in the marginal zone than in the central zone and rock fragments are more abundant in the central zone.

The heavy minerals also reflect the differences in energy distributions; the heaviest (i.e. zircon) concentrates in the high energy zones, and tourmaline and epidote in the low energy zones.

In summary, the sediment distribution is controlled almost entirely by energy regimes in the bay. The only effective variable with respect to this in the bay is wave activity.

ACKNOWLEDGEMENTS

This study was carried out for a Master's degree at the University of New South Wales in part under a Commonwealth Postgraduate Scholarship. The author wishes to acknowledge help, during all stages of the work, from Dr. A. N. Carter of the University of New South Wales and Dr. K. A. W. Crook of the Australian National University.

References

- FOLK, R. L., 1968.—*Petrology of Sedimentary Rocks*. Hemphills, Austin, Texas.
———, and WARD, W. C., 1957.—Brazos River: A study in the significance of grain-size parameters. *J. sedim. Petrol.*, 27: 3–36.
ROCHFORD, D. J., 1951.—Studies in Australian estuaries, Hydrology. *Aust. J. Mar. and Fresh-water Res.*, 2: 1–116.
ROSE, G., 1966.—Ulladulla 1–250,000 Geological Map. *New South Wales Mines Department*.
TAYLOR, G., 1970.—Sedimentation in Jervis Bay. M.Sc. thesis, Univ. N.S.W., unpubl.
WALKER, R. G., 1967.—The coastal geomorphology of the Jervis Bay Area. M.Sc. thesis, A.N.U. unpubl.